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(54) Title: AIR CLEANER WITH COARSE FILTER

(57) Abstract: A vacuum cleaner that includes a cyclone separator has a coarse filter disposed in the path of air flowing towards the outlet of the cyclone separator, for holding back hair that would otherwise tend to clog the vacuum cleaner, while minimizing impedance to air flow. In a preferred embodiment, the coarse filter comprises a disc-shaped lattice structure of barrier elements that are arranged to "catch" the animal hair.

Title: AIR CLEANER WITH COARSE FILTER

FIELD OF THE INVENTION

This invention relates generally to air cleaners of the type that include at least one cyclone separator for removing dirt from air that flows through the air cleaner.

BACKGROUND OF THE INVENTION

The invention has been devised primarily, though not exclusively, in the context of vacuum cleaners that include at least one cyclone separator for cleaning air that flows through the vacuum cleaner.

Cyclone separators, which are sometimes referred to merely as cyclones, are devices that use centrifugal force and low pressure caused by spinning motion, to separate materials of differing density, size and shape. Vacuum cleaners that include cyclone separators are disclosed, for example, in United States Patents Nos. 3,425,192, 4,593,429 and 4,643,748.

PCT Publication No. WO 00/40135 published July 13, 2000 discloses a vacuum cleaner that includes a cyclone separator in combination with a downstream electrostatic precipitator for removing fine particulate matter from the air that passes through the cyclone separator. As disclosed in this publication, the cyclone separator is removable from the vacuum cleaner as a unit and the unit includes a bin for collecting dirt that has been removed by the cyclone. The bin can be separated from the remainder of the cyclone and emptied.

Elongate filaments such as hair, particularly animal hair, represents a particular problem for vacuum cleaners. Animal hairs tend to matt together and clog or sometimes even completely block air flow through a vacuum cleaner. U.S. Patent No. 4,643,748 referred to previously discloses the use of a disc upstream of an air outlet from a cyclone separator for blocking hair filaments. However, the disc has the disadvantage that it interferes significantly with normal air flow through the cyclone.

SUMMARY OF THE INVENTION

An object of the present invention is to address the problem of hairs or other elongate filaments clogging an air cleaner, while avoiding the disadvantages encountered by the invention of U.S. Patent No. 4,643,748. In this specification, the term coarse filter or coarse filter element is used to refer to visible particulate matter that is entrained in an air stream, such as that which is picked up by a domestic vacuum cleaner, and which typically includes hair and the like. The term "coarse" is used to distinguish from the finer particle separation that is achieved by cyclone separator as well as electrostatic filtration.

In this specification, the terms up, down, top and bottom and the like are used to refer to parts of an apparatus according to the invention wherein the cyclone separator is disposed in an upright manner as shown in the figures referred to herein. It will be appreciated by those skilled in the cyclone separator art that cyclone separators may be utilized in a variety of different orientations and the coarse filter taught herein may be used in association with a cyclone separator in any such orientation.

The present invention provides an air cleaner having a dirty air inlet, a clean air outlet spaced from the dirty air inlet, an air flow path extending from the dirty air inlet to the clean air outlet and at least one cyclone separator disposed in the air flow path for receiving air from the dirty air inlet. In one embodiment, the cyclone separator has a distal wall, at least one air inlet and at least one air outlet and a coarse filter disposed in the path of air flowing to said cyclone outlet. The coarse filter includes a plurality of openings that are dimensioned and spaced so as to minimize impedance to air flowing into said cyclone outlet while tending to obstruct and retain in the cyclone chamber, elongate filaments that would otherwise enter said cyclone outlet, said coarse filter positioned adjacent said cyclone outlet and extending across at least a potion of the path of air flowing from said distal end wall to said cyclone outlet whereby at least a portion of the air passing through said cyclone separator travels longitudinally through said coarse filter.

Alternately, the cyclone separator has a cyclone chamber with a side wall having a generally cylindrical inner surface and bottom wall. A cyclone inlet is arranged to direct in-coming dirty air generally tangentially against an upper region of the inner surface of the chamber side wall so as to cause the in-coming dirty air to spiral down the inner surface of the side wall to the bottom wall. Cyclone outlet means is arranged generally centrally of an upper region of the chamber, to which air flows upwardly from the bottom wall of the chamber. Coarse filter means is disposed in the path of air flowing upwardly from the bottom wall to the cyclone inlet, inwardly of the spiral air flow adjacent the side wall of the chamber. The coarse filter means includes a plurality of barrier elements that are dimensioned and spaced so as to minimize impedance of air flowing to the cyclone outlet means while tending to obstruct and retain in the cyclone chamber, elongate filaments that would otherwise enter the cyclone outlet means.

Spaced barrier elements of the form provided by the invention have been found effective to hold back or knock out of the air flowing to the cyclone outlet means, elongate filaments such as animal hair while not substantially affecting air flow overall.

The coarse filter means may be in the form of a disc-shaped structure comprising a lattice of barrier elements. In this embodiment, the barrier elements may be shaped to define a plurality of spaced concentric rings with straight barrier elements extending angularly outwardly and connecting the rings. In a further embodiment, the disc-shaped lattice structure may be provided with a depending skirt of lattice form for preventing migration of hair or other filaments outwardly around the disc-shaped structure.

In accordance with another embodiment of this invention, the coarse filter has a sleeve or skirt that extends from the coarse filter element to the inlet or openings of the clean air outlet of the cyclone. This sleeve or skirt preferably has openings to permit air to pass there through but to retain elongate filaments such as animal hair while not substantially affecting air flow overall.

BRIEF DESCRIPTION OF DRAWINGS

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which illustrate a number of preferred embodiments of the invention by way of example, and in which:

Fig. 1 is a perspective view of an upright vacuum cleaner in accordance with one embodiment of the present invention;

Fig. 2 is a perspective view of the filter assembly of the vacuum cleaner in accordance with one embodiment of the present invention;

Fig. 3 is a partial vertical sectional view through the filter assembly shown in Fig. 2, showing the coarse filter element of the embodiment of Fig. 2;

Fig. 4 is a perspective view illustrating an alternative embodiment of coarse filter element;

Fig. 5 is a perspective view of the filter assembly of the vacuum cleaner in accordance with another embodiment of the invention;

Fig. 6 is a partial vertical sectional view through the filter assembly shown in Fig. 5, showing the coarse filter element of the embodiment of Fig. 5;

Fig. 7 is a partial vertical sectional view through the filter assembly shown in Fig. 5, showing a further alternate embodiment of the coarse filter element of the invention;

Fig. 8 is a perspective view of the filter assembly of the vacuum cleaner in accordance with another embodiment of the invention;

Fig. 9 is a partial vertical sectional view through the filter assembly shown in Fig. 8, showing a further alternate embodiment of the coarse filter element of the invention; and,

Fig. 10 is a partial vertical sectional view through the filter assembly shown in Fig. 8, showing a further alternate embodiment of the coarse filter element of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to the drawings, Fig. 1 shows an upright vacuum

cleaner in accordance with a preferred embodiment of the present invention. The vacuum cleaner and its manner of operation are generally in accordance with the disclosure of PCT Publication No. WO 00/40135 referred to previously, to which reference may be made for specific details not found in the present disclosure.

The vacuum cleaner is generally denoted by reference numeral 20 and includes a floor cleaning head 22 that is mounted on wheels, one of which is visible at 24, for movement over a floor surface. A dirty air inlet in the underside of the head is indicated at 26 and usually will accommodate a driven rotary brush or beater bar (not shown). Extending upwardly from a rear portion of the head 22 is a support structure 28 for a filter assembly 30 that is removable as a unit from the vacuum cleaner. The filter assembly is shown separately in Fig. 2.

Above the filter assembly, the support structure 28 carries an upper body portion 32 of the vacuum cleaner that incorporates a fan and motor assembly (not shown) for drawing air through the vacuum cleaner and delivering cleaned air to a clean air outlet 34 at the top of body portion 32. A handle for manoeuvring the vacuum cleaner is indicated at 36.

The filter assembly 30 may include two cleaning stages which are preferably a cyclone separator generally denoted by reference 38 and an electrostatic air filter 40 enclosed in a housing 42 (see, e.g., Fig. 2). A cyclone chamber C is defined by a dirt collection bin 44. Bin 44 has a cylindrical side wall 46 that is preferably transparent. Visible through the side wall of the bin is the internal structure 48 of the cyclone separator. This includes a main inlet pipe 50 that extends upwardly centrally of bin 44 and through which dirty air enters the cyclone from the floor cleaning head 22 of the vacuum cleaner.

Pipe 50 extends upwardly and then laterally to a cyclone inlet opening 52 that directs air tangentially with respect to the internal surface of the side wall 46 of bin 44. When the vacuum cleaner is in use, air entering bin 44 from inlet 52 spirals downwardly on the internal surface of bin side wall 46 until it reaches a lower baffle member or distal end wall 54 (Fig. 2),

which deflects the air inwardly and upwardly adjacent the outer surface of inlet pipe 50. Member 54 forms a bottom wall of the cyclone chamber C. The air then passes through a coarse filter element F (to be described) before entering openings 56 in an upper housing 58 of the cyclone separator and then flowing upwardly through the electrostatic filter 40. This air flow is generally indicated by the ghost outline arrows 60. The air then travels upwardly through filter 40 and leaves the filter assembly 30 through an opening 62 in the top of filter housing 42.

Referring back to Fig. 1, the flow path of air from the dirty air inlet 26 of head 22 to the clean air outlet 34 of the vacuum cleaner is indicated at 64. To summarize, the air travels upwardly through inlet pipe 50 of the cyclone separator to the inlet 52 of the cyclone, from where it spirals downwardly adjacent the inner surface of the side wall 46 of the cyclone bin. The air then travels back up adjacent the outer surface of inlet pipe 50 and into the openings 56 of the housing 58 of the cyclone assembly. The air then travels upwardly through filter 40, and through the upper body portion 32 of the vacuum cleaner to outlet 34.

Filter assembly 30 (Fig. 2) is preferably removable from the remainder of the vacuum cleaner in the manner disclosed in the PCT application referred to previously, by slightly depressing the filter assembly and then pulling it outwardly. As best seen in Fig. 3, the filter assembly housing 42 has a top surface that is angled upwardly to the right and that is shaped to provide a handle 66 that projects forwardly of the vacuum cleaner in the assembled condition, as best seen in Fig. 1. Thus, the user grasps the handle 66, depresses the filter assembly slightly and pulls it forwardly and outwardly using the handle. Fig. 2 shows the filter assembly as it would appear after removal from the remainder of the vacuum cleaner in this fashion.

When the vacuum cleaner is in operation, dirt that is removed from the air flowing through the vacuum cleaner by the cyclonic action of the cyclone separator accumulates in bin 44. The upper housing 58 of the cyclone assembly and the housing 42 of the filter 40 fit together to form a

sub-assembly that also includes the inlet pipe 50 of the cyclone separator and baffle 54 (Fig. 2). The housings 42 and 58 have the same cylindrical exterior configuration and fit together so that the sub-assembly forms a cylindrical closure that is a push-fit inside the upper portion of cyclone bin 44. The sub-assembly can be separated from the cyclone bin 44 by lifting the sub-assembly from the bin. Bin 44 can then be emptied of accumulated dirt.

In accordance with the present invention, a coarse filter F (referred to previously) is provided in the path of air flowing upwardly from the bottom wall 54 of the cyclone chamber to the cyclone outlet represented by the openings 56 in the upper housing 58 of the separator. As shown in the embodiments of Fig. 2 and 3, the coarse filter includes a plurality of barrier elements that are dimensioned and spaced so as to minimize impedance of air flowing to the cyclone outlet while tending to obstruct and retain in the cyclone chamber C, elongate filaments such as animal hairs that would otherwise enter the cyclone outlet. Filter F in effect tends to knock the hairs out of the air that is flowing to the cyclone outlet and retain the hairs in bin 44 for disposal.

In the particular embodiment illustrated in Fig. 2, the filter F comprises a disc-shaped lattice structure that is mounted at the top of the cyclone inlet tube 50 as best shown in Fig. 3. The barrier elements take the form of a series of spaced concentric ring-shaped barrier elements 68 connected by a series of straight barrier elements 70 that extend radially outwardly with respect to inlet pipe 50. For example, the lattice structure representing filter F may be a plastic moulding and the barrier elements may be relatively fine circular section plastic strands or filaments.

As best seen in Fig. 3, the filter F has an external diameter that is sufficiently less than the internal diameter of bin 44 so as not to significantly interfere with and, preferably, not interfere with, in-coming air that enters the cyclone chamber C through inlet 52 and then spirals down the internal surface of bin 44.

Fig. 4 shows an alternative embodiment of the invention in

which the disc-shaped lattice structure of Fig. 2 is provided with a depending skirt 72 which is itself made up of a lattice of barrier elements, comprising vertically spaced circular elements 74 and angularly spaced upright barrier elements 76 that connect the circular elements 74. It is believed that, in some applications, the skirt 72 will inhibit migration of hairs outwardly around the edge of the filter F.

Figs. 5 and 6 show a further alternate embodiment of the invention. In this embodiment, coarse filter F also includes an upwardly extending skirt 78 having openings 80 provided therein. Skirt 80 is configured to enclose the openings 56 such that air can not by pass the end 82 of the disc shaped portion of filter F and enter directly into openings 56. As shown in Figs. 5 and 6, skirt 78 is cylindrical and extends from the upper surface 84 of the disc shaped portion of filter F to upper housing 58. In the alternate embodiment of Fig. 7, skirt 78 is conical in shape. It will be appreciated that skirt 78 may be a variety of shapes provided that it does not significantly interfere with the cyclonic air flow in bin 44. Openings 78 may be a variety of shapes. For example, openings 80 may be constructed in a similar manner to the disc shaped portion of filter F by means of barrier elements. Alternately, skirt 78 may be constructed from a solid material and openings 80 may be in the nature of perforations in the solid wall. In either event, openings 80 are dimensioned and spaced so as to minimize impedance of air flowing to the cyclone outlet while tending to obstruct and retain in the cyclone chamber C, elongate filaments such as animal hairs that would otherwise enter the cyclone outlet. Skirt 78 may be constructed as a one piece mold with the disc shaped portion of filter F. Alternately, skirt 78 could be constructed as a separate assembly. For example, in the embodiment of Fig. 6, skirt 78 could be constructed from sheet metal which is wrapped around openings 56 to create an air tight seal with filter F and upper housing 58.

Figs. 8 and 9 show a further alternate embodiment of the invention. In this embodiment, coarse filter F also includes an upwardly extending skirt 78 having openings 80 provided therein. The configuration of

skirt 78 and openings 80 may be the same as discussed with respect to the embodiments of Figs. 5, 6 and 7. In this embodiment, portion 86 of coarse filter F exterior to skirt 78 is solid. Portion 88 of filter F interior to skirt 78 has openings 80 therein. Thus, depending upon the diameter of inner portion 88 and the size of openings 80, at least a portion of the air travelling to the cyclone outlet passes upwardly through openings 80 of inner portion 88 and enters openings 56.

It has been found in practice that the provision of coarse filter means as taught herein including a plurality of barrier elements of the form provided by the invention minimizes impedance to air flowing to the cyclone outlet while tending to obstruct and retain in the cyclone chamber, hairs and other elongate filaments that would otherwise enter the cyclone outlet. This in turn avoids or minimizes any tendency for the hairs to matt and clog the air flow through the vacuum cleaner.

The coarse filter may have a shape other than the shapes specifically shown for filter F, for example an umbrella, bell or other curved shape.

It is to be understood that the preceding description relates to particular preferred embodiments of the invention only and that various additions and modifications are possible, some of which have been indicated previously and others of which will be apparent to a person skilled in the art. In particular, it is to be noted that the invention is applicable to any type of vacuum cleaner whether upright (as illustrated), canister vacuum cleaner or central vacuum cleaner or the like. The dirty air stream which is processed may be collected, for example, by a wand or rotating brush positioned in the head of the vacuum cleaner as is known in the art. The invention may also be used with a wet/dry vacuum cleaner. The material separated by the cyclone separator of the vacuum cleaner may be removed from the vacuum cleaner by any alternate means known in the art. For example, the cyclone separator may have an opening therein to permit the separated material to be removed or the separated material may be transported to a removal station by means of a manually operate auger or

the like. In the latter case, the cyclone separator need not be separable from the vacuum cleaner for routine emptying in which case an access port may be provided for cleaning the coarse filter of accumulated material as may be required.

The filter assembly may include more than one cyclone separator. In such a case, one or more cyclone separators may be used in place of electrostatic air filter 40 or as a supplement to electrostatic air filter 40. For example, the filter assembly may include a plurality of cyclones, some of which or each of which has a coarse filter as taught herein. The filter assembly may comprise a plurality of cyclonic separation stages that may be operated in series or parallel and, preferably, in series. In such a case, the first cyclonic separation stage may comprise a single cyclone separator and the second cyclonic separation stage may comprise a plurality of cyclone separators. Electrostatic air filter 40 could optionally be incorporated in the air flow stream between the first and second cyclonic separation stages or downstream from the second cyclonic separation stage.

Finally, it should be noted that, while the disclosure with reference to the drawings is directed exclusively to vacuum cleaners, the invention may be applied to other forms of air cleaner, for example a room air cleaner. In this latter context, an air filter assembly, for example, of the form shown in Fig. 2 could form part of a room air cleaner in which air is caused to flow upwardly through the filter assembly and out into the room through opening 62.

I CLAIM:

1. An air cleaner having

(a) a dirty air inlet,

(b) a clean air outlet spaced from the dirty air inlet,

(c) an air flow path extending from the dirty air inlet to the clean air outlet,

(d) at least one longitudinally extending cyclone separator disposed in said air flow path for receiving air from said dirty air inlet, the cyclone separator comprising a cyclone chamber having a side wall with an inner surface and a distal end wall, a cyclone inlet, a cyclone outlet and a coarse filter disposed in the path of air flowing to said cyclone outlet, wherein in-coming dirty air spirals along said inner surface of the side wall to said distal end wall,

(e) said coarse filter including a plurality of openings that are dimensioned and spaced so as to minimize impedance to air flowing into said cyclone outlet while tending to obstruct and retain in the cyclone chamber, elongate filaments that would otherwise enter said cyclone outlet, said coarse filter positioned adjacent said cyclone outlet and extending across at least a potion of the path of air flowing from said distal end wall to said cyclone outlet whereby at least a portion of the air passing through said cyclone separator travels longitudinally through said coarse filter.

2. An air cleaner as claimed in claim 1, wherein said coarse filter means comprises a disc-shaped lattice structure defined by barrier elements.

3. An air cleaner as claimed in claim 2, wherein said barrier elements comprise a series of spaced concentric circular barrier elements connected by an angularly spaced series of elements that extend radially of the cyclone chamber.

4. An air cleaner as claimed in claim 3, wherein the coarse filter further comprises a skirt that depends from the outer perimeter of said disc-shaped lattice structure and that itself comprises a series of spaced barrier elements.

5. An air cleaner as claimed in claim 4, wherein said barrier elements defining the skirt comprise a series of vertically spaced circular elements interconnected by a series of angularly spaced vertical elements.

6. An air cleaner as claimed in any one of claims 2 to 5, wherein the coarse filter comprises a plastic moulding which includes said barrier elements.

7. An air cleaner as claimed in any one of claims 2 to 6, wherein said cyclone separator includes an air inlet pipe that extends upwardly centrally of the cyclone chamber to said cyclone inlet, and wherein said filter element is carried by said pipe.

8. An air cleaner as claimed in any one of claims 1, 4, 6 or 7, wherein said coarse filter further comprises a disc shaped portion and a skirt that extends from said disc portion towards said distal wall.

9. An air cleaner as claimed in claim 1, wherein said coarse filter further comprises a disc shaped portion and a skirt that extends from said disc portion towards to enclose said cyclone outlet.

10. An air cleaner as claimed in claim 1, wherein said skirt extends from said disc shaped portion at an intermediate portion of said disc shaped portion such that a portion of said disc shaped portion extends exterior to said skirt.

11. An air cleaner as claimed in claim 10, wherein said portion of said disc shaped portion that extends exterior to said skirt is solid.

12. An air cleaner as claimed in any one of claims 1, 8, 9, 10, wherein the skirt is cylindrical.

13. An air cleaner as claimed in any one of claims 1, 8, 9, 10, wherein the skirt is conical.

14. A vacuum cleaner having

(a) a dirty air inlet,

(b) a clean air outlet spaced from the dirty air inlet,

(c) an air flow path extending from the dirty air inlet to the clean air outlet,

(d) at least one cyclone separator disposed in the air flow path for receiving air from said dirty air inlet, the cyclone separator having a distal wall, at least one air inlet and at least one air outlet,

(e) a coarse filter disposed in the path of air flowing to said cyclone outlet, the coarse filter including a plurality of openings that are dimensioned and spaced so as to minimize impedance to air flowing into said cyclone outlet while tending to obstruct and retain in the cyclone chamber, elongate filaments that would otherwise enter said cyclone outlet, said coarse filter positioned adjacent said cyclone outlet and extending across at least a potion of the path of air flowing from said distal end wall to said cyclone outlet whereby at least a portion of the air passing through said cyclone separator travels longitudinally through said coarse filter.

15. A filter assembly for an air cleaner, which includes at least one cyclone separator disposed in the air flow path for receiving air from said dirty air inlet, the cyclone separator having a distal wall, at least one air inlet and at least one air outlet, a coarse filter disposed in the path of air flowing

to said cyclone outlet, the coarse filter including a plurality of openings that are dimensioned and spaced so as to minimize impedance to air flowing into said cyclone outlet while tending to obstruct and retain in the cyclone chamber, elongate filaments that would otherwise enter said cyclone outlet, said coarse filter positioned adjacent said cyclone outlet and extending across at least a potion of the path of air flowing from said distal end wall to said cyclone outlet whereby at least a portion of the air passing through said cyclone separator travels longitudinally through said coarse filter.

FIG. 1.

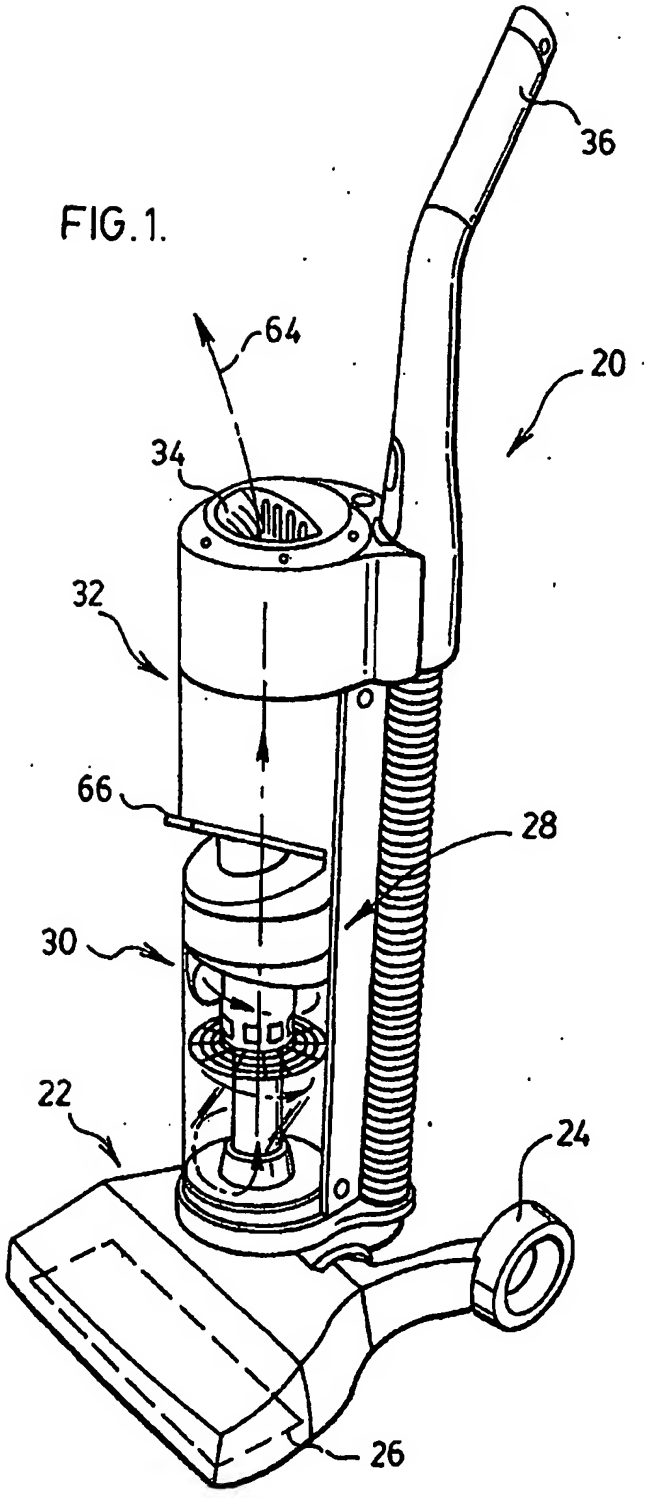
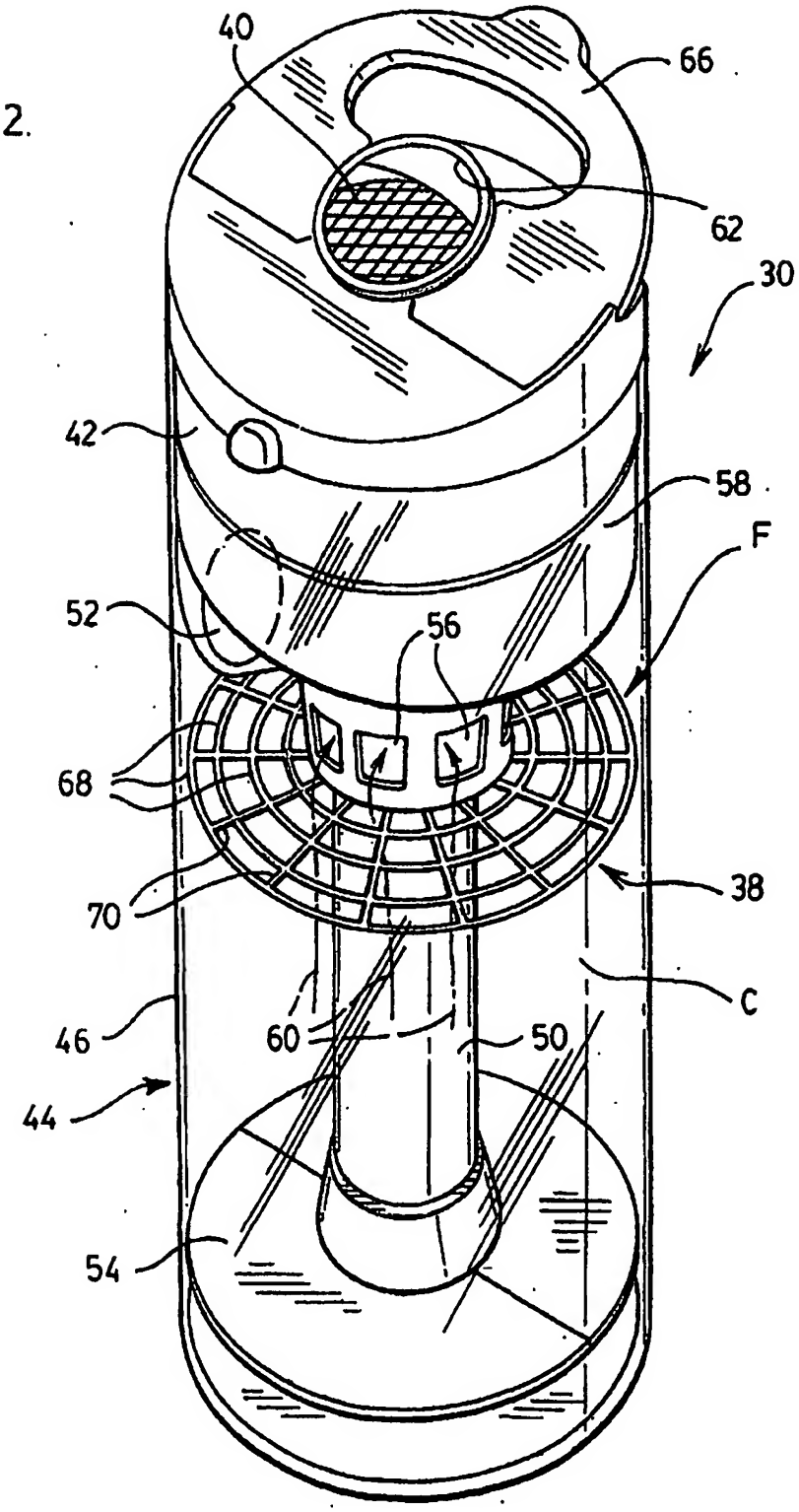


FIG. 2.



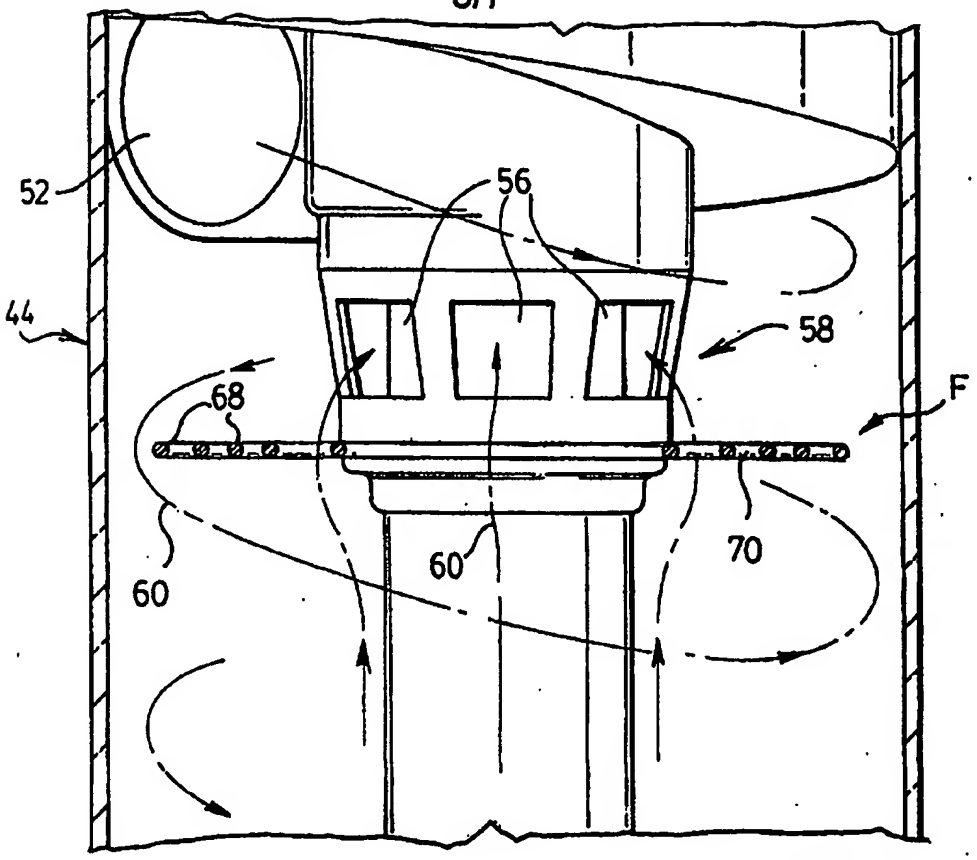


FIG. 3.

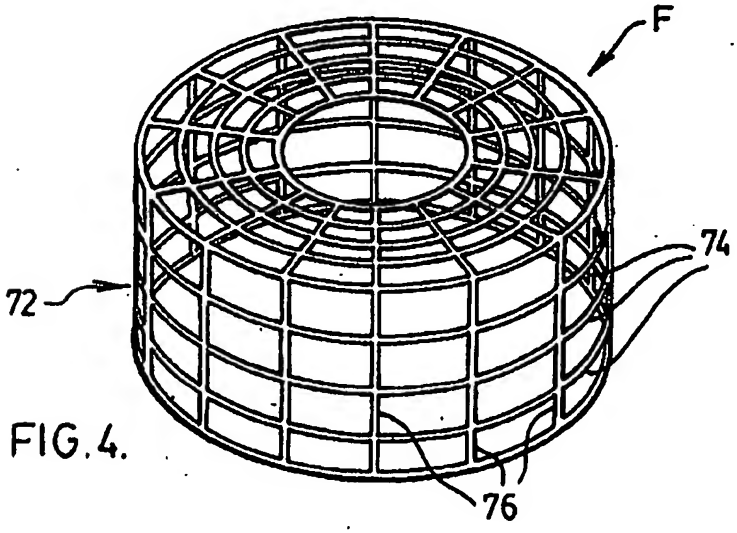
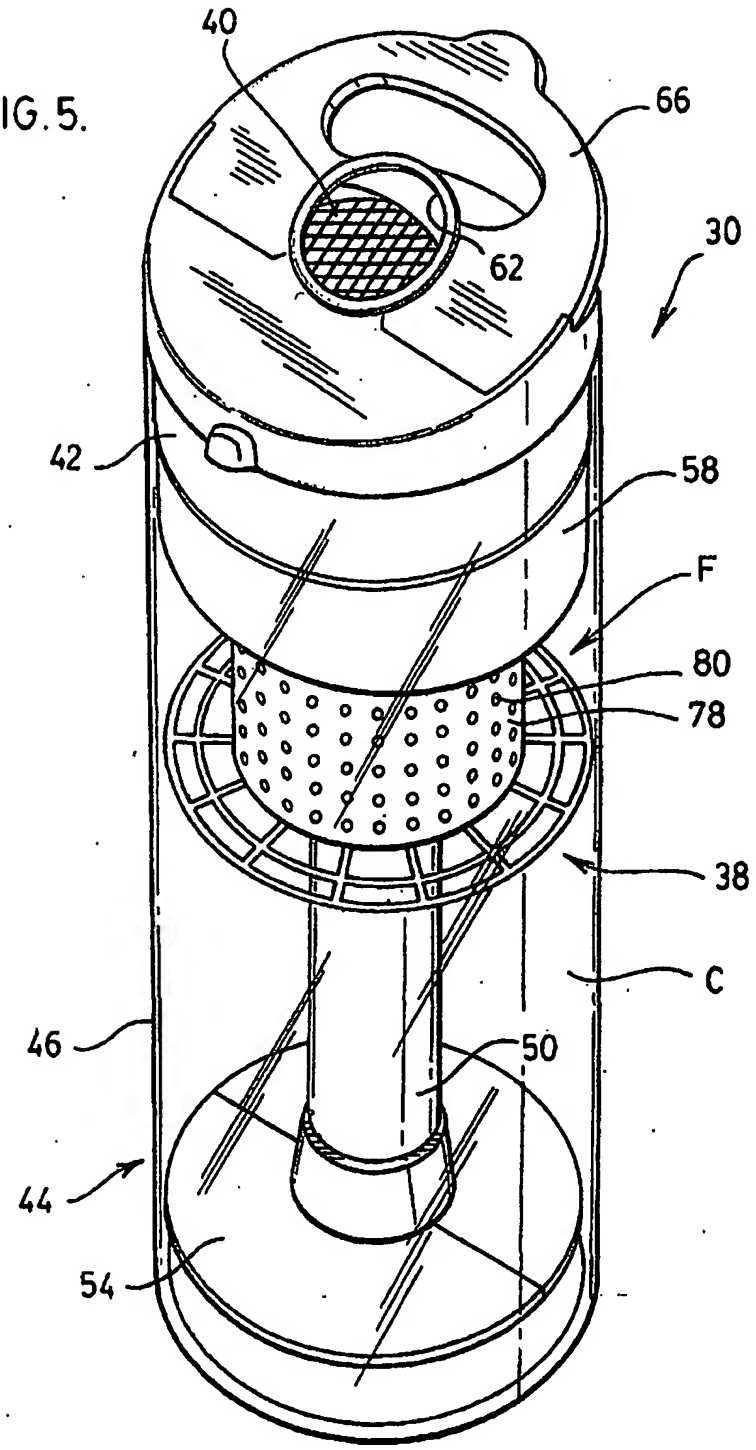


FIG. 4.

FIG. 5.



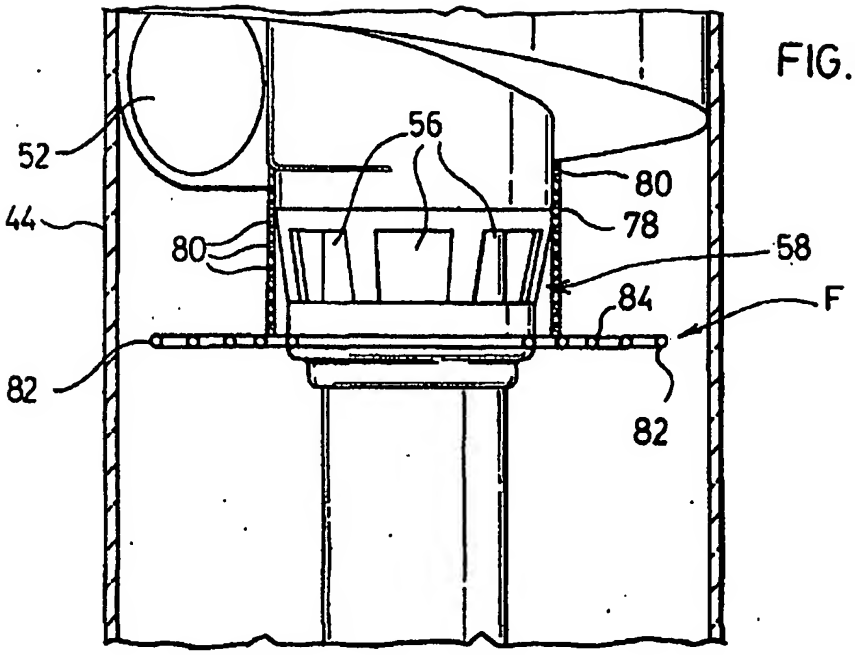


FIG.6.

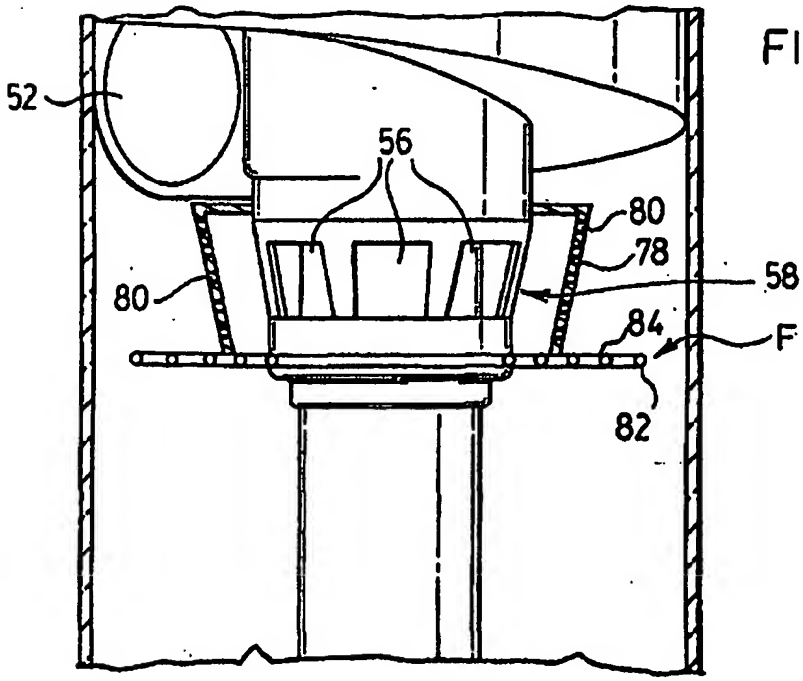
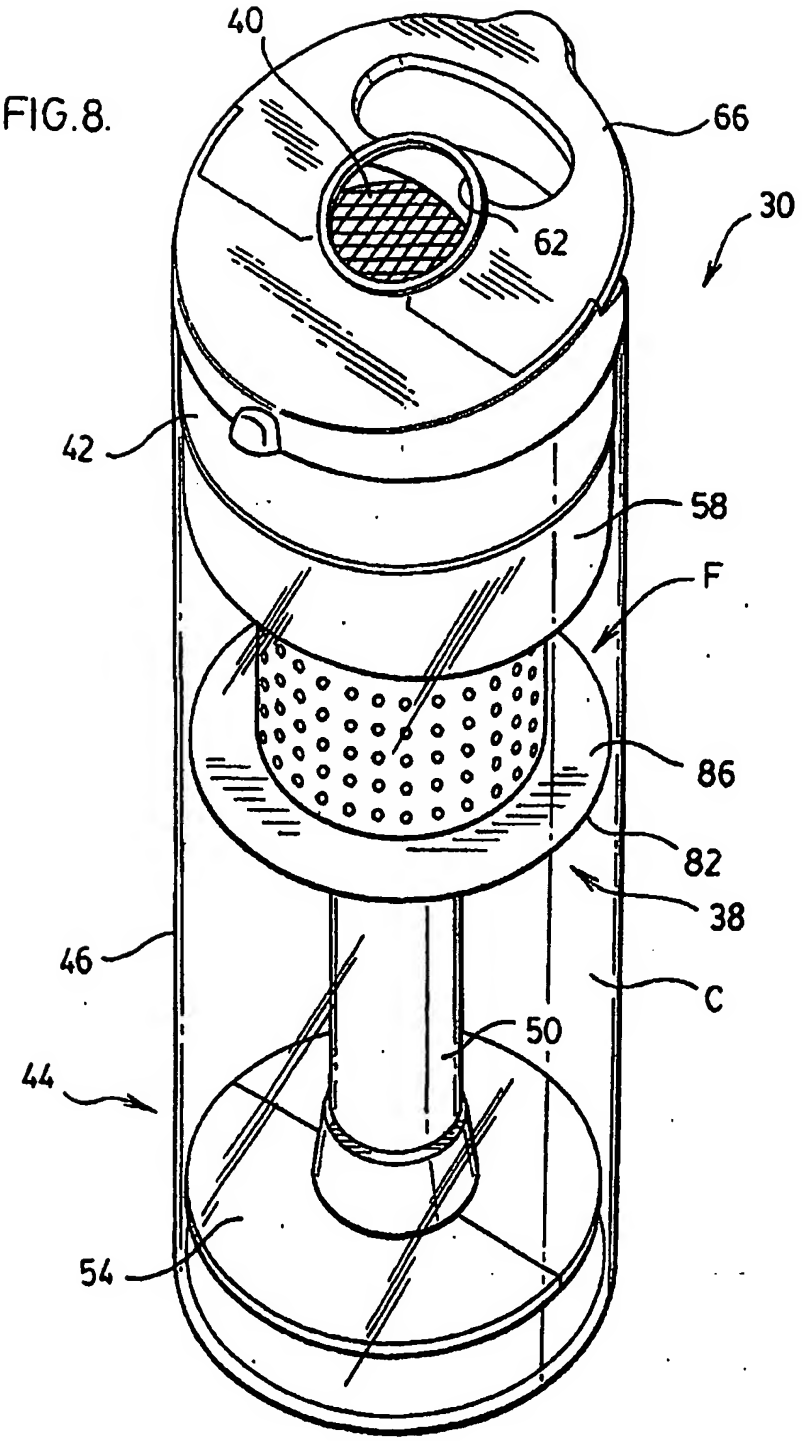


FIG.7.

FIG.8.



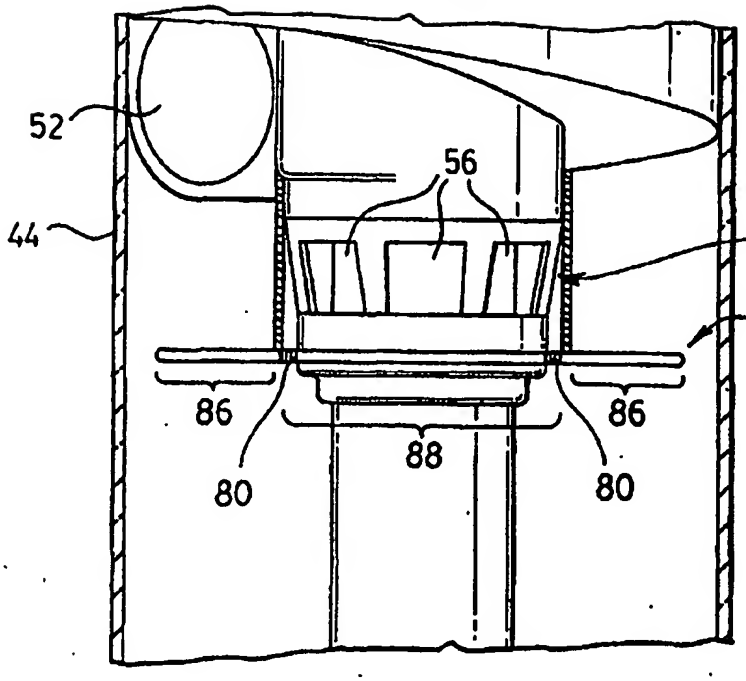


FIG.9.

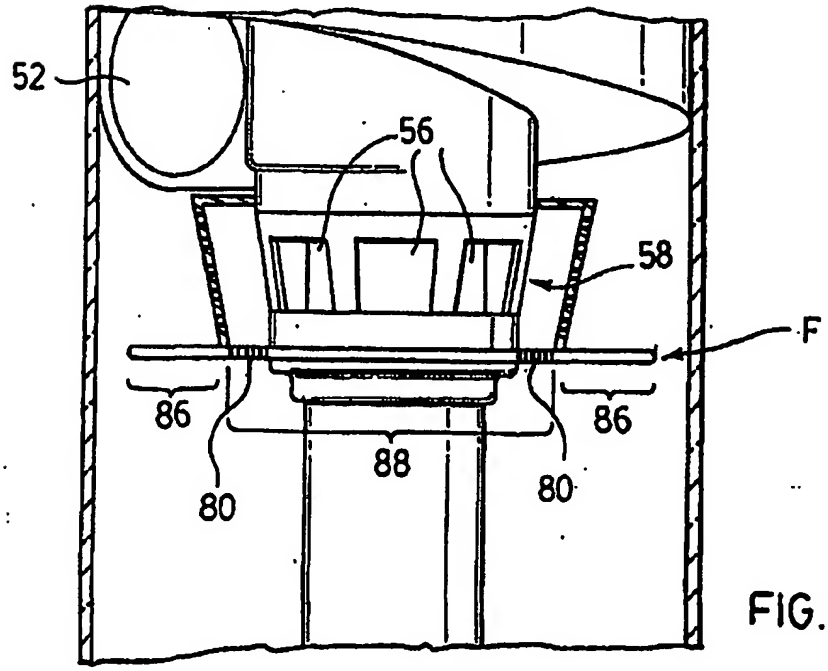


FIG.10.